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Quantum Gravity and String Theory

Lecture Notes for Teaching Mechanistic Quantum Field Theory Axiomatically

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The purpose of these brief lecture notes is to provide the basic framework for a course in axiomatically-derived mechanistic quantum field theory, to teach the foundations needed to understand vixra paper 2606.0012. Problems and solutions will be developed for inclusion at a later date, after we have more experience in teaching this course to students.

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Sorry, I made the following small LaTeX typesetting typing errors (which will be corrected in the revised notes at some later time when problems and solutions are included to turn it into a textbook): page 6, section 2.2:

both V(k) propagators are missing 4Pi, e.g. for massless propagator (Coulomb):

V(k) = 4Pi/k^2;

for massive propagator

V(k) = 4Pi/(k+m)^2.

However these examples are trivial and qualitative and in this kind of physics it is common to use a shorthand where all small dimensionless multipliers (like 2, 4 and Pi, etc) are ignored (i.e. set equal to unity). Similarly, at pages 7 and 15 in section 7.2, I've missed a factor of 1/2 from the Taylor expansion.

There's a more substantive by still not physically significant maths error on pages 9 and 31 in the Laplacian transformation: it should be done using integration by parts.

Let u = exp(-kr), so du = -k exp(-kr) dr, and dv = d(R^2 dV/dr)dr which yields v = (r^2)dV/dr. Then applying integration by parts (∫ u dv = uv − ∫ v du), and using a negative Laplacian, we eventually end up with V(k) = 4Pi/(k^2 + m^2). Finally, Appendix G.1 should point out that normalization of the four-velocity flips (u^μ)(u_μ) = -1, upon moving past the branch cut into the Lorentzian FLRW coordinate branch. What concerns me more is getting examples of practical calculations written down, e.g. the Lamb shift occurs very simply because of vacuum polarization and gauge boson aka "virtual" particle exchange:

The ~1 GHz Lamb shift, discovered in 1947 using the microwave frequency technology from radar invented in WWII, requires renormalizing the mass of the electron. Bethe was able to find an order-of-magnitude estimate of the lamb shift, namely E = [(4Z^4 α^5 m)/(3πn^3)][ln(Λ_{UV}/Λ_{IR})], where the logarithmic running of mass is included by using the ratio of the high energy cutoff, Λ_{UV}, to the low energy cutoff Λ_{IR}; the former (high energy or "ultra violet" aka UV cutoff) being the observed rest mass energy of the electron 511,000 eV, and the later the low energy or infrared (IR) cutoff equal to the ground state energy level of the electron in a hydrogen atom, 13.6 eV. But Bethe had to fiddle this by reducing the IR cutoff below 13.6 eV to make it agree with Lamb's measurement. The correct Lamb shift theory was then independently discovered by Feynman and Schwinger, and Tomonaga in Japan. Dyson showed that all three were equivalent and differed from Bethe's estimate! Bethe had neglected the spin-orbit correction term!

This Lamb shift mechanism is not merely "technical trivia": the Lamb shift discovery was the key experiment that motivated the vital path integral development of QED and thus later developments in QFT leading to the SM, proving the reality of so-called "virtual particles," and that all electrons acquire mass while interacting with the background quantized elecomagnetic field by exchange of "virtual photons". In both the Lamb shift in electron's energy level, and the so-called "anomalous" magnetic moments of leptons, the electron loses energy - and thus some of its mass - briefly by emitting a "virtual particle", then interacts with the background electromagnetic field, before "reabsorbing" the "virtual particle" it earlier emitted. Mass renormalization is needed therefore since at the time of the interaction, the electron has briefly lost mass! The amplitudes for various possibilities can be visually drawn as Feynman diagrams (the probabilities are proportional to the square of the amplitude for each diagram). This is not fiction or "merely theory", but hard experimentally proven fact.

The problem is that today's textbooks treat it, along with other QFT examples such as scattering amplitude calculations (easily calculated using the propagator and renormalized charge aka "coupling" in Feynman's rules), as abstract mathematical barrel organ machine magic, not simple mechanical vacuum dynamics.

Section 13: some kind feedback from group theorist Professor Robert Wilson on his Hidden Assumptions blog on 26 June 2026 suggests the following changes:

SO(3,3) ⊂ SU(4) isn’t “strictly” correct, but what I meant is that sl(4,C) has the compact real form SU(4), while the spin group of SO(3,3) is SL(4,R), so

SO(3,3) ⊂ SU(4)

really means, in my rough thinking:

SL(4,R) ⊂ sl(4,C)

If you want 6 and 9 dimensions:

SU(4) ⊃ U(3)

SO(4) ⊃ U(3)

coset SU(4)/U(3)

dim SU(4) = 15

dim U(3) = 9

I don't believe Professor Wilson should count up the number of photon polarizations, since "real" photons" are not, according to the path integral, fundamental particles. They're just uncancelled superpositions, composites. So I don't believe the "Hidden Assumptions" author's claim that there is "no mechanism for creating complex linear combinations of horizontal and vertical polarisations, and circular polarisation. So we must have 9 photons and 6 neutrinos."

I think that because neutrinos change flavour during propagation, they're composite too. Instead, I see the 9 generators of U(3) as encoding colour and chirality gauge structure, and the 6 coset directions of SU(4)/U(3) correspond to vacuum-polarization modes that generate distinct fermion branches. This seems to work.

SO(6) ≃ SU(4) is the real form of SL(4,C) and general relativity's SL(4,R) emerges from that after Wick rotation.

SU(3,1) spacetime is 4-dimensional QM, but I don't believe in 4 dimensions with complex metrics: see https://ai.vixra.org/pdf/2606.0054v1.pdf for one way to make QM Euclidean (there are probably other proofs too). Professor Wilson's latest blog post, Complexifying the Complex states: "You have to first ask the question, whether spacetime is mathematical or physical. ... Spacetime is not a physical concept, but it is an essential mathematical abstraction that underlies all physical theories. But different physical theories (in particular, relativity and quantum mechanics) treat spacetime in different ways, that are mathematically inconsistent. This has nothing to do with physics, unless or until you want to construct a unified (mathematical) theory that incorporates both relativity and quantum mechanics. At that point, you have to reconcile the two different mathematical definition of spacetime. Which means replacing one of them by the other."

I simply don't agree with the "it's pure mathematics at the bottom of the pile of turtles that supports the world" prejudice for the simple reason Feynman gave in 1964 Cornell lectures The Character of Physical Law: IT TAKES AN INFINITE PERTURBATIVE EXPANSION AND THUS INFINITE COMPUTING POWER TO PREDICT PRECISELY THE PATH OF AN ELECTRON IN THE ATOM USING PATH INTEGRALS (an infinite number of Feynman diagrams, aka terms in the perturbative expansion of QFT). This debunks the notion that the "universe is mathematical". Sure, you use equations to approximate numerical values, but that doesn't prove there is no mechanism.

Also, it's completely obvious that, if space and time are truly symmetric, there are 3 time and 3 spatial dimensions as Lunsford argued in "Gravitation and Electrodynamics over SO (3,3)," Int. J. Theor. Phys., v. 43 (2004), No. 1, pp.161-177

Please also see the discussions at https://www.math.columbia.edu/~woit/wordpress/?p=128&cpage=1#comment-1920 for evidence of its censorship by arXiv after peer-review, which to me indicates it's of value (at least as a threat to mainstream theory)!